GMI Aerosol Module Intercomparison II: 2-D Model Intercomparison of Modal and Sectional Aerosol Approaches

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Microphysical Modules:

AER: 40 bins, 0.39 nm - 3.2 μm, 2x volume

UMaer: 3 modes, 2 moments, fixed lognormal widths

Nucleation (Vehkamaeki et al., 2002): $\frac{dN}{dt}, \frac{dM}{dt}$

Coagulation: $\frac{dN}{dt} \sim r_{vol}$

Condensation/Evaporation: $\frac{dM}{dt} \sim r_{vol}$

Sedimentation: $\frac{dN}{dt} \sim r_{eff1}, \frac{dM}{dt} \sim r_{eff2}$

Summary of Box Model Intercomparison

360 cases: 850, 500, 200, 50 mb

January and July conditions, extrema in T, RH, SO_4

10 day integrations

Herzog et al. (2004) JGR 2003JD004405

2-modes, 4-modes, 40 bins vs 150 bins

4-mode version within factor of 1.2 of 150 bin model

2-D Intercomparison in AER Framework: Stratosphere and Troposphere

Sulfate aerosol only - *Tropospheric aerosol not realistic*

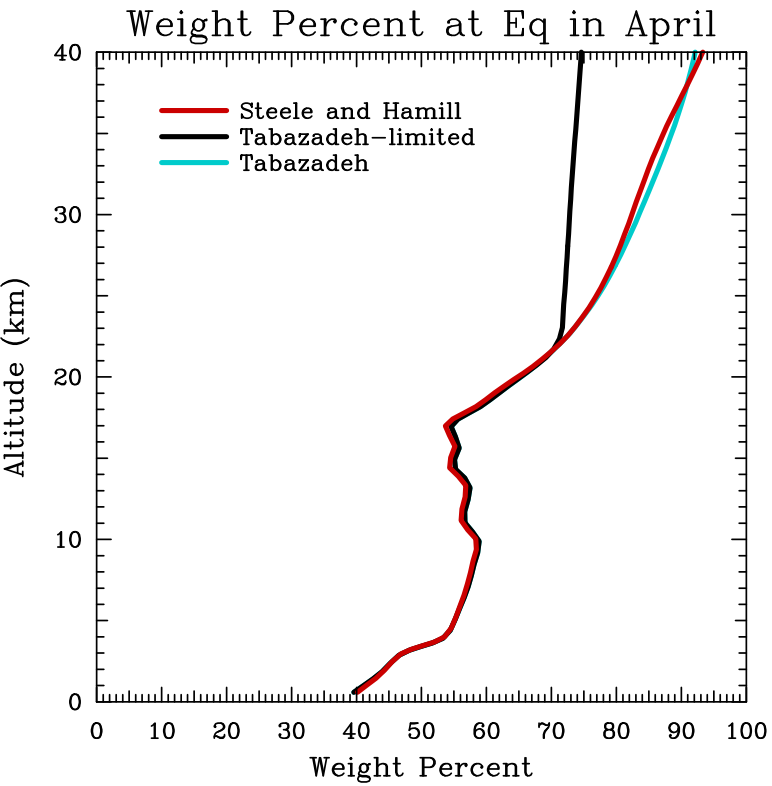
Pole to Pole, 0-60 km, 9.5° x 1.2 km

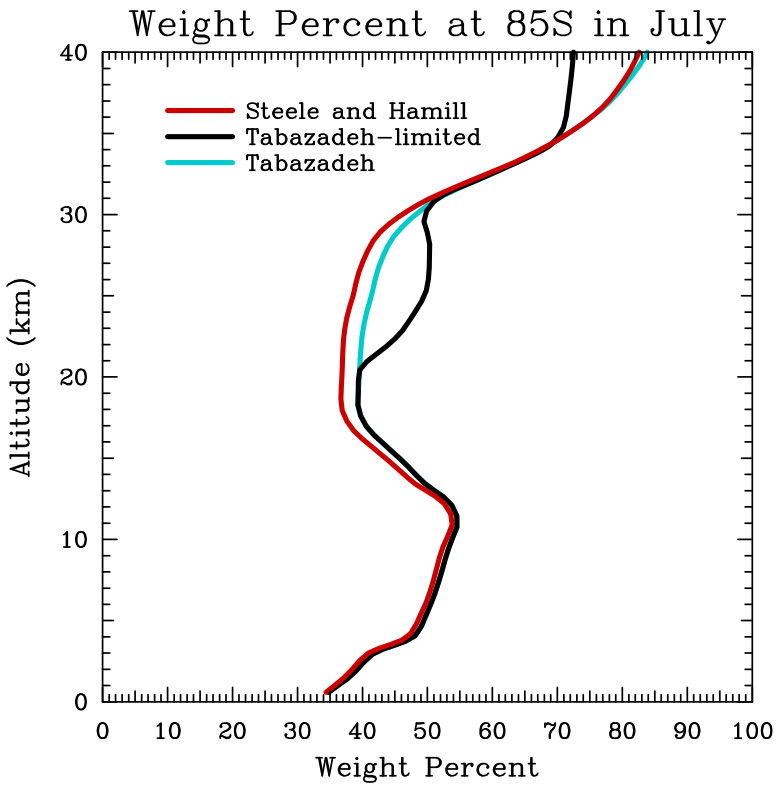
Transport: Advection, Eddy Diffusion,
Sedimentation (accumulation from above)

Multi-year integrations to steady-state

Timing: 3-modes runs 53 minutes/year with dynamical time steps
40 bins runs 104 minutes/year with 1 hour time step
40 bins runs 417 minutes/year with 15 minute time step
AER used 20 substeps over nucleation and condensation

Previous Problems Diagnosed

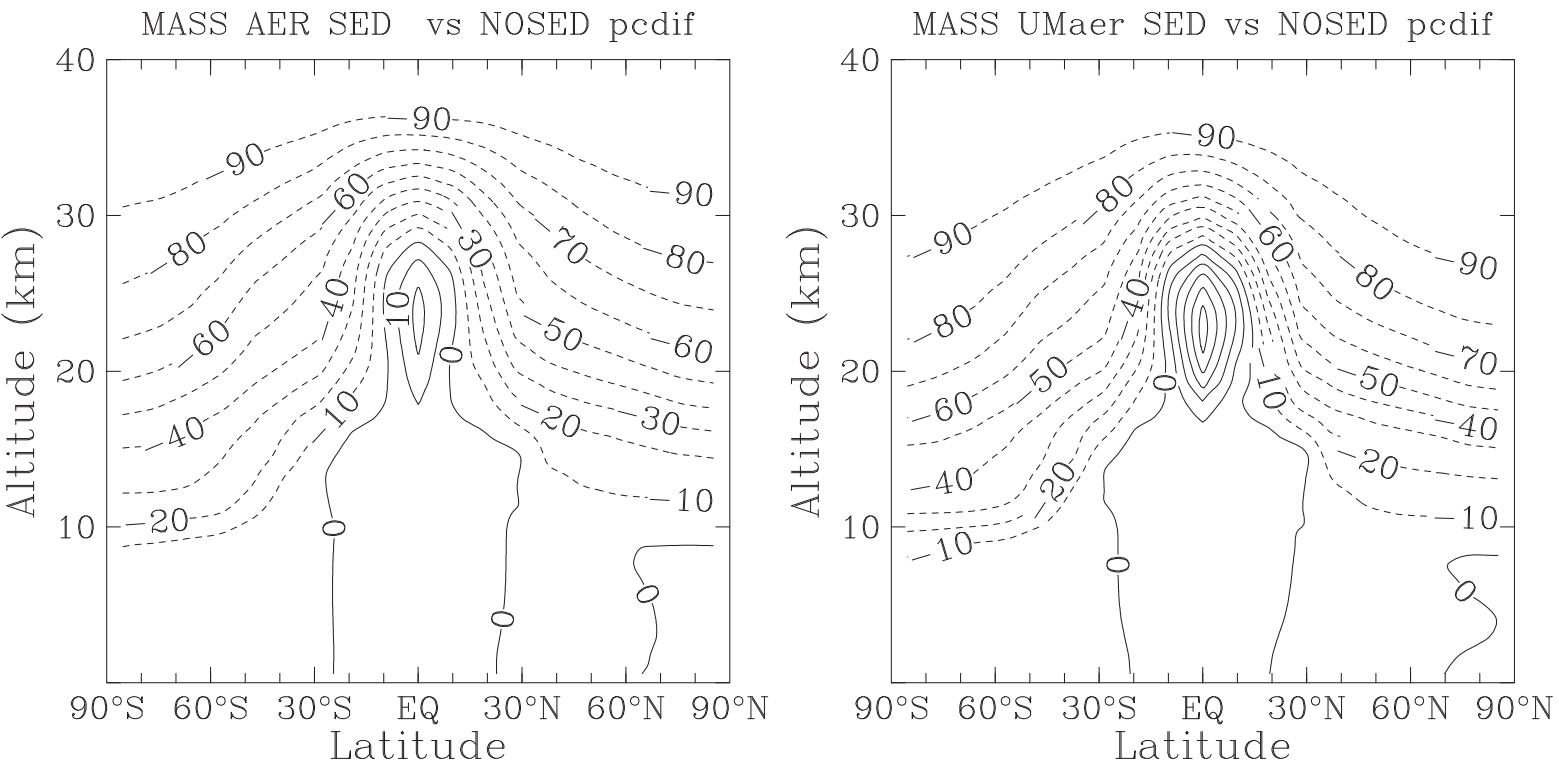




UMaer limited 1%<RH<100%, AER no lower limit

Limited RH resulted in limited WP, minimal evaporation

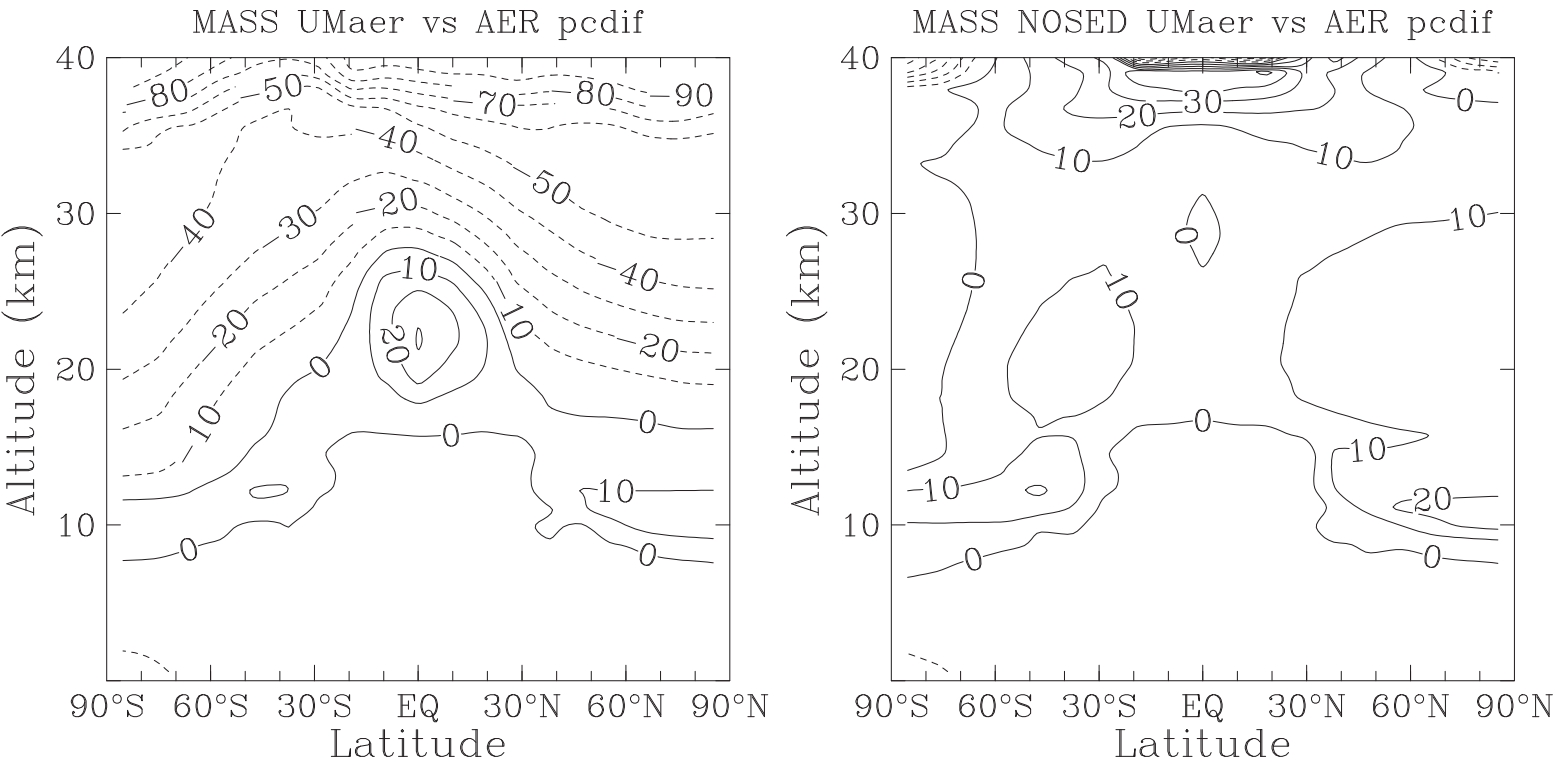
Sedimentation Effect on Mass Density, Annual Average



Sedimentation balances upwelling in tropics at 20-25 km

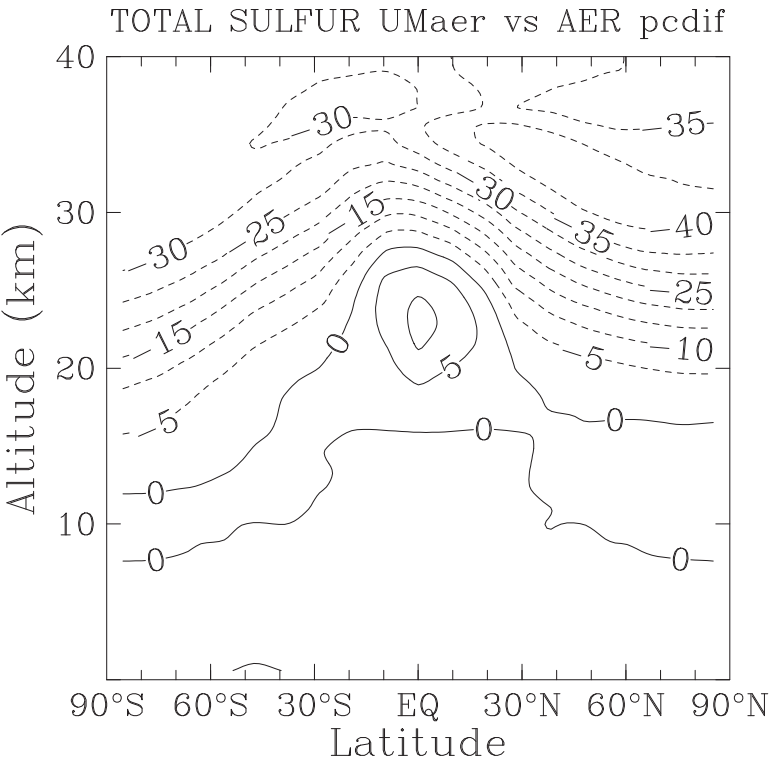
Sedimentation has somewhat bigger impact in UMaer

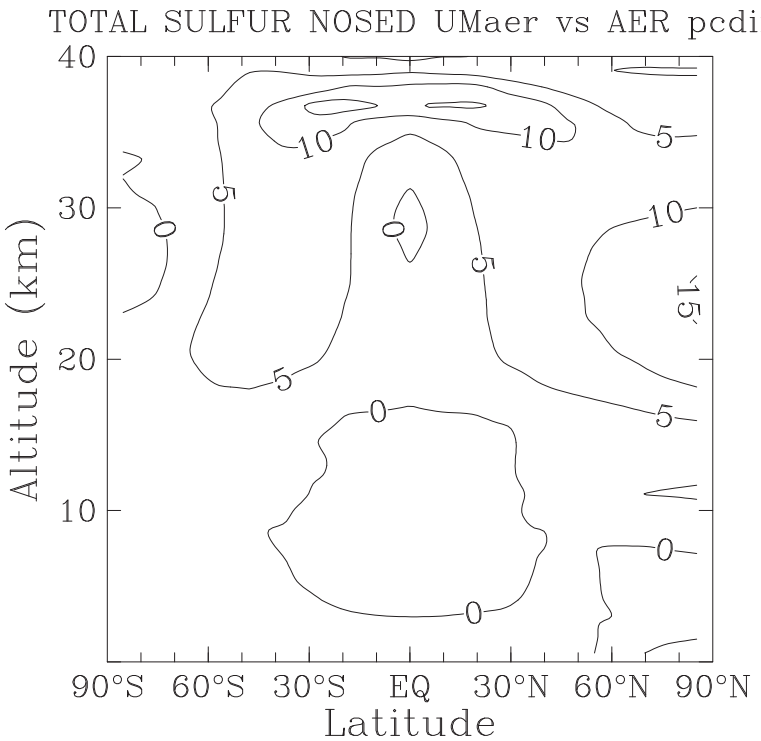
Mass Density Comparison, Annual Average



Strat burdens same with sed, UMaer +10% without sed

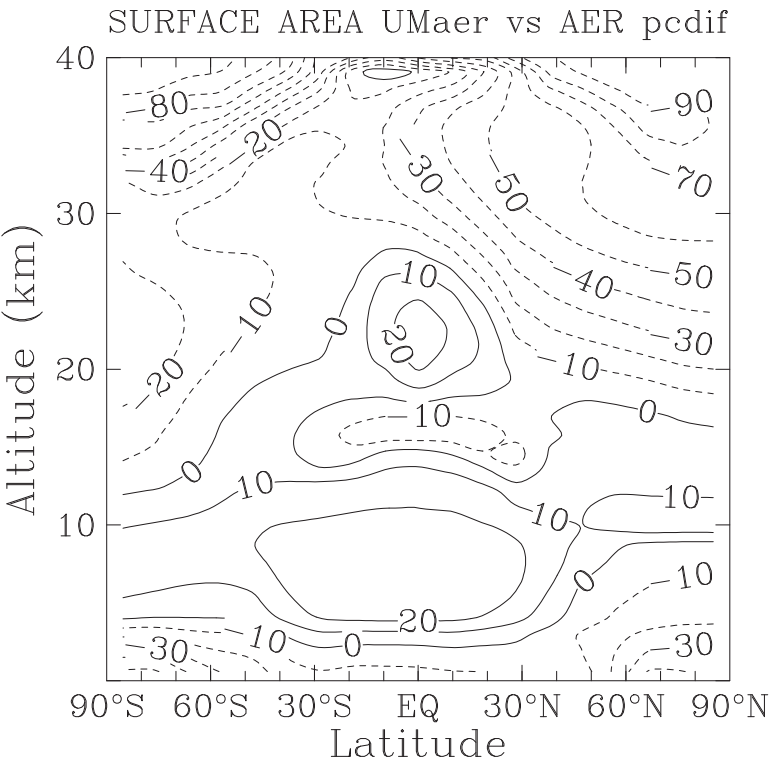
Total Sulfur Comparison, Annual Average

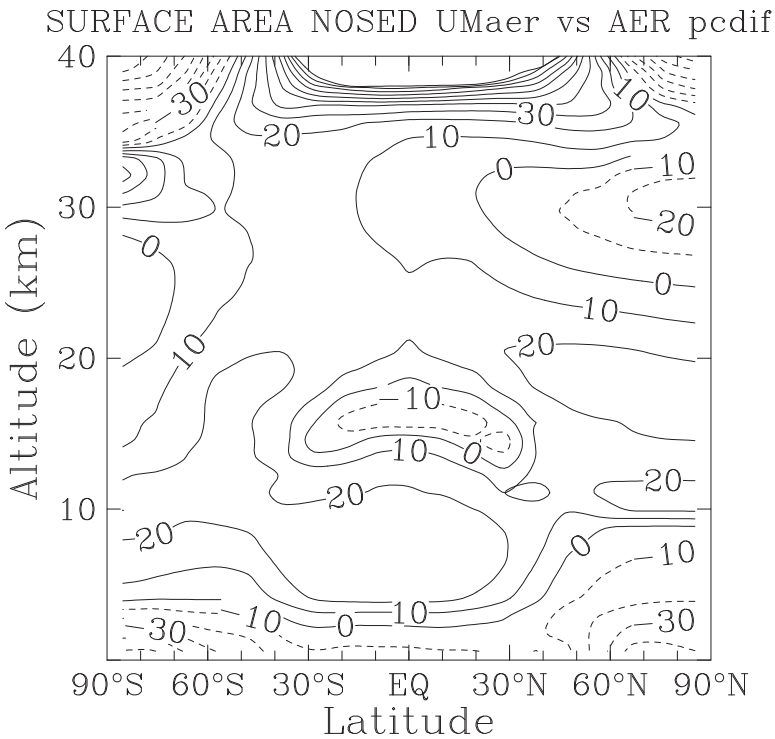




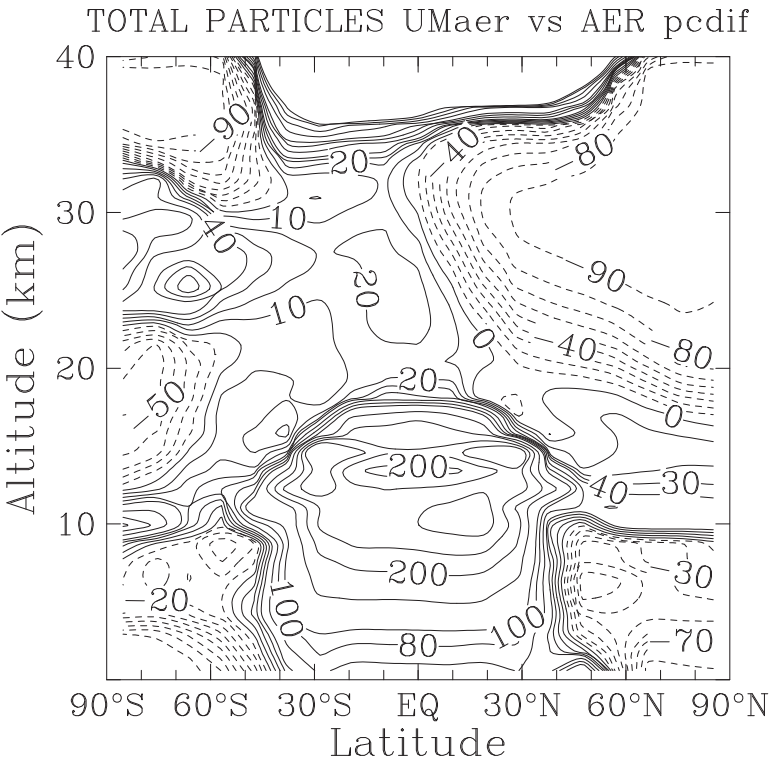
Gas+aerosol sulfur removes differences in evaporation/condensation

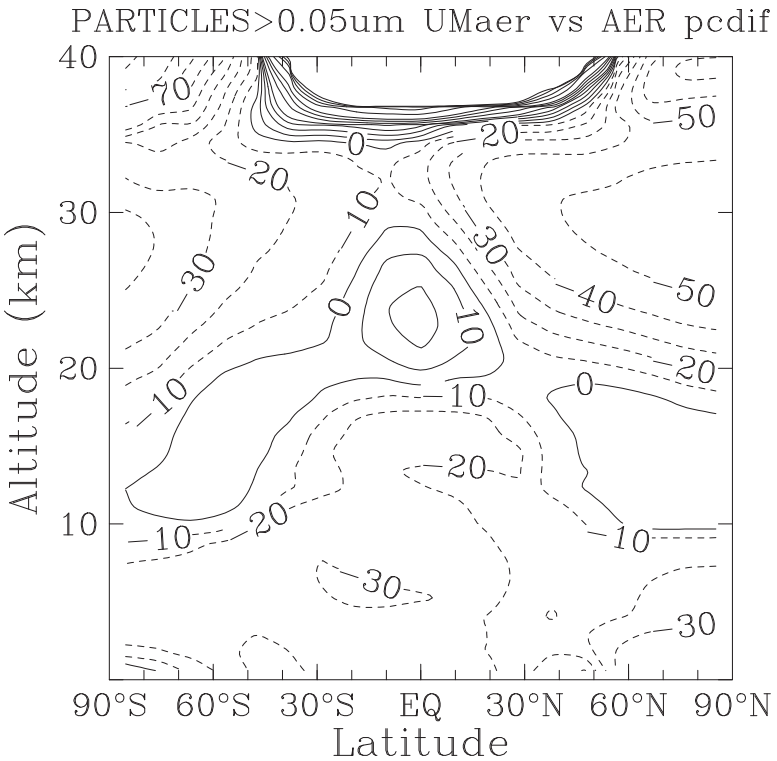
Surface Area Comparison, Annual Average



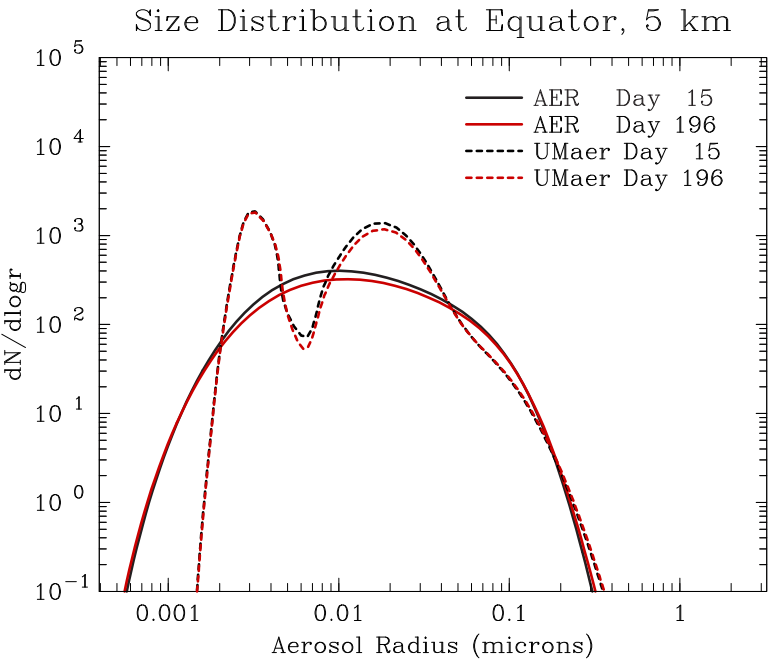


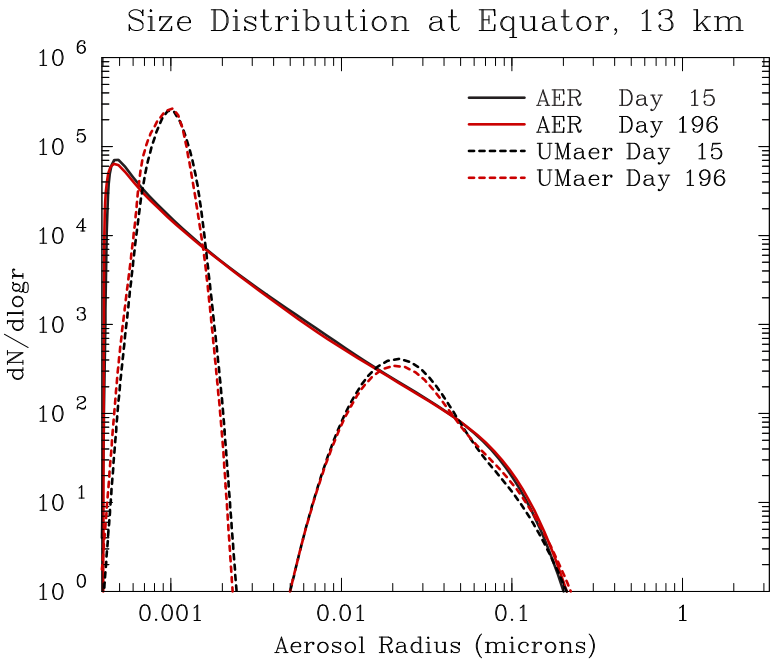
Particle Number Density Comparison, Annual Average





Size Distribution at Equator, Troposphere

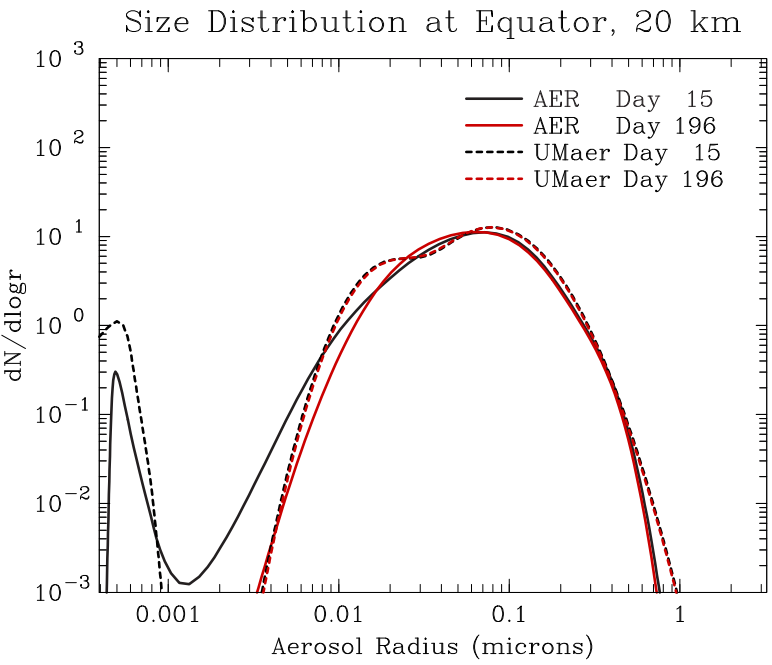


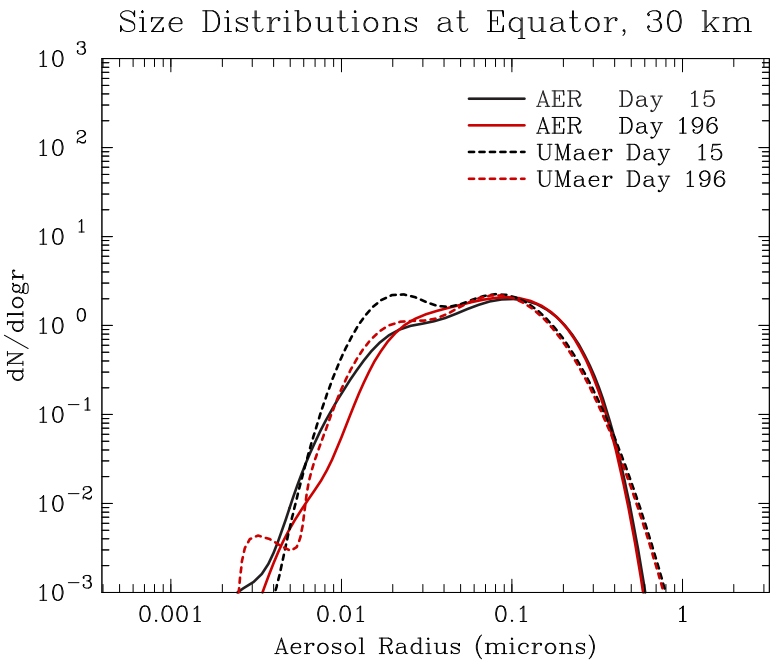


5 km: UMaer Mass -2%, SAD +29%, N>0.05 -31%

13 km: UMaer Mass -3%, SAD +12%, N>0.05 -19%

Size Distribution at Equator, Stratosphere

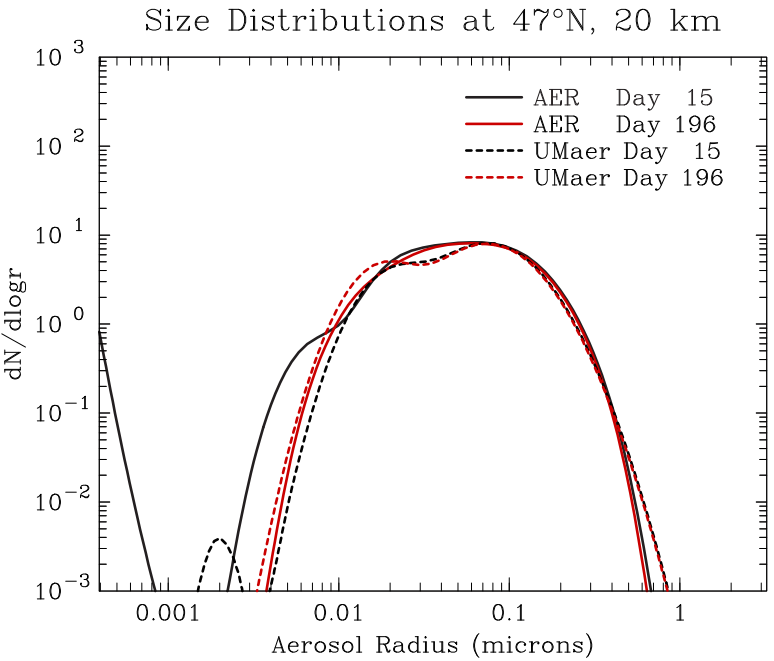


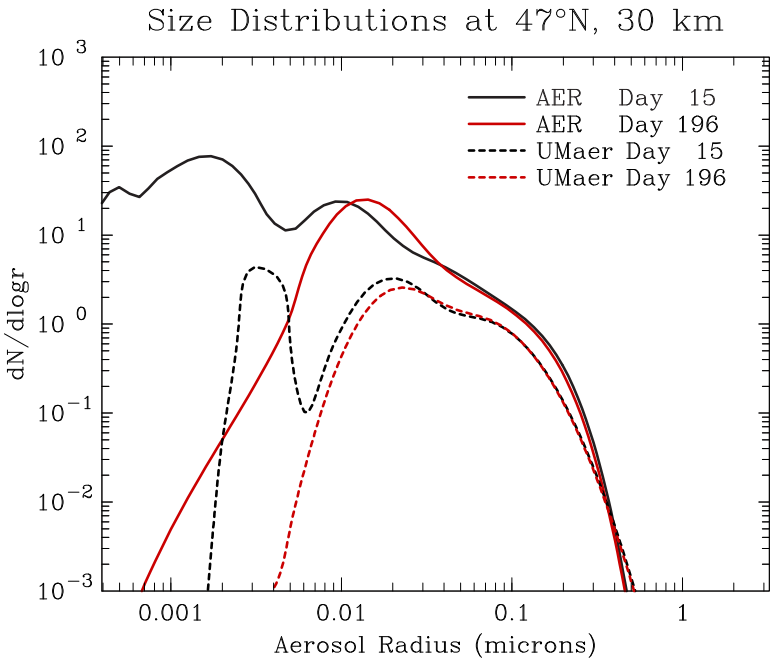


20 km: UMaer Mass +28%, SAD +23%, N>0.05 +15%

30 km: UMaer Mass -15%, SAD -15%, N>0.05 -6%

Size Distribution at 47°N, Stratosphere





20 km: UMaer Mass -9%, SAD -11%, N>0.05 -10%

30 km: UMaer Mass -48%, SAD -58%, N>0.05 -51%

Summary and Conclusions

- UMaer module with 3 modes sucessfully implemented in AER 2-D model
- AER slower by 2x (1 hr step) or 8x (15 min step)
- Models obtain similar global aerosol burdens
- Sedimentation more efficient in UMaer $\Longrightarrow$ less mass above 20 km
- Integrated aerosol quantities (Mass, SAD) within 20% below 20 km
- Particle number densities may deviate by large amounts, but numbers with r>0.05 μm within 20-30% below 20 km

Future Work

- Implement non-sulfate aerosols in 2 modes for each type: oc, bc, dust, ss
- Coagulation between 2-mode non-sulfate particles and sulfate particles in 40 bins
- Implement 40 bin scheme in GMI with same interface as UMaer